Some flowers visited by the Australian Painted Lady *Vanessa kershawi* (Nymphalidae, Lepidoptera) in northern Sydney bushland

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Abstract

Adults of the Australian Painted Lady *Vanessa kershawi* were recorded visiting the flowers of 17 species of plants for nectar, in bushland of northern Sydney, New South Wales, Australia. More than half of these were native plants, predominantly in the family Myrtaceae. Most of the plants visited were dicotyledons. The growth forms of the plants visited by *V. kershawi* ranged from herbs, through to shrubs and one species of tree. All native flowers visited by *V. kershawi* were white or cream coloured. Flowers of weed species visited were white, yellow, purple or orange. Tubular, cup-shaped and dish-shaped or open flowers were fed upon by *V. kershawi*. In the wild, ready availability of nectar may be the overriding factor in determining flower selection by *V. kershawi* adults. *V. kershawi* may play a role in the pollination of many of the 17 plant species recorded in this study. As a migratory butterfly species, *V. kershawi* may be involved in the long range dispersal of the pollen of a number of common native and exotic plant species. (*The Victorian Naturalist* **123** (6), 2006, 352-361)

Introduction

The Australian Painted Lady *Vanessa kershawi* (family Nymphalidae, subfamily Nymphalinae) is a very common, medium-sized butterfly occurring throughout south-eastern Australia and also in parts of central and western Australia (Braby 2000; Braby 2004). Adults of *V. kershawi* have been observed for much of the year in southern New South Wales (NSW) and Victoria, with peak abundance in spring, but are apparently absent from there in mid-winter (Braby 2000). The adults of *V. kershawi* are migratory and have been observed moving in large numbers, especially in spring (Smithers and Peters 1966; Smithers 1969; Common and Waterhouse 1981; Braby 2000; Braby 2004). The larvae of *V. kershawi* feed almost exclusively on various native and introduced species of plants in the daisy family (Asteraceae) (Braby 2000; Edwards *et al.* 2001).

Some information has been published about the diet of adult *V. kershawi*. For example, Hawkeswood (1981) listed seven introduced species of plants whose flowers were visited by *V. kershawi* adults in the Glenbrook area of the lower Blue Mountains, NSW, in the summertime. He listed Cobbler's Pegs *Bidens pilosa*, Coreopsis *Coreopsis lanceolata*, Tall Fleabane *Erigeron floribundus* (= ?*Conyza albida*), Stinking Roger *Tagetes minuta* and Dandelion *Taraxacum officinale* (all in the Asteraceae), Japanese Honeysuckle *Lonicera japonica* (Caprifoliaceae) and *Pavonia hastata* (Malvaceae) as adult food plants of *V. kershawi*. Nunn (2002) mentioned that the introduced daisy species Smooth Catsear *Hypochoeris glabra* and Lesser Hawkbit *Leontodon taraxacoides* were commonly visited for nectar by *V. kershawi* in the Ballarat region of Victoria. Williams and Powell (2006) observed *V. kershawi* feeding on the flowers of Capeweed *Arctotheca calendula* (Asteraceae) on Woody Island, off the coast of southern Western Australia.

A few authors have noted some native plants fed upon by *V. kershawi* adults. Keighery (1975) recorded *V. kershawi* as a visitor to the flowers of Coastal Banjine *Pimelea ferruginea*, Rose Banjine *P. rosea* and *P. sulphurea* (all in the Thymelaeaceae) in Western Australia. Stace and Fripp (1977) observed *V. kershawi* visiting white-flowered plants of Common Heath *Epacris impressa* (Epacridaceae) in spring in eastern Victoria. *Vanessa kershawi* was recorded foraging on the flowers of Plunkett Mallee *Eucalyptus curtisii* (Myrtaceae) in Queensland (Dunn 1994). Williams and Powell (2006) observed adults of *V. kershawi* feeding on the flowers of *Pimelea ferruginea* and of Variable Groundsel *Senecio lautus* (Asteraceae), on islands of the Recherche Archipelago in

Western Australia. Braby and Edwards (2006) frequently observed *V. kershawi* adults feeding from the flowers of daisies (Asteraceae) and Eucalypts (Myrtaceae) in the Griffith district of inland southern NSW.

The aim of this present study was to find out which species of plants weare visited for nectar by *V. kershawi* adults in the bushland of northern Sydney.

Observations and Discussion

Observations for this study were made in the Lane Cove River catchment area of northern Sydney, NSW, in the years 1995-1998 and 2003-2005. Much of the natural vegetation in the study area is open-forest, with smaller amounts of woodland and heathland also present (Clarke and Benson 1987; Benson and Howell 1990). The open-forests of the study area are dominated by a few species of eucalypt, most commonly Sydney Peppermint *Eucalyptus piperita*, Red Bloodwood *Corymbia gummifera* and Sydney Red Gum *Angophora costata*. The understoreys of these forests are often shrubby and floristically diverse, with the families Proteaceae, Fabaceae, Myrtaceae and Rutaceae strongly represented. These plant families also dominate woodland and heathland within the study area. Herbs, sedges, grasses and subshrubs are most evident in areas that have recently been burnt. Keith (2004, pp 146-147) provided a general description of the Sydney Coastal Dry Sclerophyll Forests, which are typical of most of the study area's surviving vegetation. In the study area, watercourses and disturbed places (such as the edges of bushland) are frequently dominated by introduced weed species, e.g. Small-leaved Privet *Ligustrum sinense* (Oleaceae) and Lantana *Lantana camara*. The observations for this study were made in sclerophyllous vegetation, mostly growing on sandstone. Harden (1990-1993) was consulted as the main authority for plant names to be used in this paper.

In the course of this fieldwork, *V. kershawi* adults were recorded feeding on the nectar of 17 species of plants (Table 1). On most occasions the butterflies were observed inserting their proboscises into the flowers and it was assumed that this indicated that they were feeding on nectar. Some instances have been included where a butterfly moved from flower to flower in a manner highly consistent with nectar feeding, but I was unable to observe whether it inserted its proboscis into the flowers. In these cases it was inferred that the butterfly was probably feeding on nectar. However, it is worth noting that butterflies may occasionally land on flowers without feeding on their nectar.

Of the 17 species visited by *V. kershawi*, ten were native species, predominantly belonging to the family Myrtaceae (Figs 1 and 2). Other native plants visited were in the families Thymelaeaceae, Colchicaceae (Liliaceae *s. lat.*) and Xanthorrhoeaceae. All of the native plants visited are common species within the study area, except for *Melaleuca styphelioides*, which is locally rare. The introduced plant species visited by *V. kershawi* were from the families

Fig. 1. *Vanessa kershawi* feeding on nectar of *Kunzea ambigua* (Myrtaceae).

Fig. 2. *Vanessa kershawi* foraging on flowers of *Angophora hispidia* (Myrtaceae).

Table 1. Some flowers visited by the Australian Painted Lady *Vanessa kershawi* for nectar, in the bushland of northern Sydney. An asterisk before the plant species name indicates an introduced plant, occurring either in bushland or in weed thickets and patches of weeds associated with bushland.

Family / Species	Growth Form	Flower Colour	Flower Shape	Month(s) of Feeding by *V. kershawi* Adults
Dicotyledons				
Asteraceae				
**Ageratina adenophora*	herb	white	(florets) tubular	October
**Coreopsis lanceolata*	herb	yellow	tubular	December
**Senecio madagascariensis*	herb	yellow	tubular	November
Rosaceae)				
**Cotoneaster glaucophyllus*	shrub	white	'cup'	November
Myrtaceae				
Angophora hispida	tall shrub	white	'dish'	December
Eucalyptus piperita	tree	white	'cup'	January
Kunzea ambigua	tall shrub	white	'cup'	Oct., Nov., Dec.
Leptospermum polygalifolium	shrub	white	'dish'	November
Leptospermum trinervium	shrub	white	'dish'	October
Melaleuca styphelioides	tall shrub	white	short tube	November
Oleaceae				
**Ligustrum sinense*	tall shrub	white	short tube	October, November
Thymelaeaceae				
Pimelea linifolia	shrub	white	tubular	Sept., Oct., Nov., Dec., Jan.
Verbenaceae				
**Lantana camara*	tall shrub	orange	tubular	October
**Verbena bonariensis* (s. lat.)	herb	purple	tubular	November
Monocotyledons				
Colchicaceae (Liliaceae s.lat.)				
Burchardia umbellata	herb	white	open	October
Xanthorrhoeaceae				
Xanthorrhoea arborea	_	white	open	January, February
Xanthorrhoea media	_	white	open	October

Asteraceae (Fig. 3), Rosaceae, Oleaceae and Verbenaceae. Most of the flowers visited were dicotyledons. Only three of the species visited were monocotyledons. This list is by no means exhaustive and could be expanded by more intensive and widespread observations. Even so, it begins to give some idea of the diet of adults of *V. kershawi* in the bushland of northern Sydney. *Vanessa kershawi* was not seen feeding on plant sap in the study area.

Flower Shape

Faegri and van der Pijl (1979) suggested that the 'typical' butterfly blossom has a narrow tube and a flat 'rim', e.g. *Lantana* and *Buddleja*. They also recognised that butterflies are able to feed on other flower types. In addition, they stated that butterflies frequently feed on the florets of daisies. Rutowski (2003) indicated that flower shape is important to butterflies in learning which flowers to visit for nectar.

The flowers visited by *V. kershawi* in northern Sydney bushland ranged from tubular in shape to 'cup'-shaped, 'dish'-shaped, or open. The only native species with tubular flowers visited by *V. kershawi* was Slender Rice Flower *Pimelea linifolia*. Armstrong (1979) listed a number of butterfly species, recorded as visiting *Pimelea* flowers. Hawkeswood (1981) noted that *P. linifolia* was visited for nectar by many adult butter-flies at Glenbrook. *Pimelea*

linifolia is commonly visited by many different species of butterfly in the bushland of northern Sydney, including *V. kershawi* (pers. obs.). *Pimelea linifolia* often flowers abundantly in the understorey of northern Sydney's bushland in the first few years after fire, when its nectar is probably an important food for adult butterflies, including *V. kershawi*.

Most of the native flowers visited by *V. kershawi* in northern Sydney bushland were 'cup' or 'dish'-shaped and easy to access for a wide range of nectar-feeding insects, including butterflies. These native plant species were mostly in the family Myrtaceae. For example, the Dwarf Apple *Angophora hispida* has very broad, large and 'open' flowers that attract a diverse and abundant array of insects (Fig. 2), in the bushland of Sydney (Musgrave 1972; Benson and McDougall 1998; pers.obs.). Other 'open', or readily accessible, flowers visited by *V. kershawi* in northern Sydney bushland include those of the Broad-leaf Grass-tree *Xanthorrhoea arborea* and of *X. media* (Xanthorrhocaceae). The flowers of *A. hispida* and *X. media* are usually abundantly produced only in the first year or so after fire (Benson and McDougall 1998, 2005; pers. obs.).

The flowers of the weed species visited by *V. kershawi* were predominantly tubular, though the Small-leaved Privet *Ligustrum sinense* has very short floral tubes and the daisies visited also have rather short tubular florets.

Theoretically, *V. kershawi* might be expected to experience more competition for nectar from other insects (e.g. bees, beetles and flies) at the more open flowers. However, in practice such competition often may not be an important factor. Most of the observed visits to 'open' flowers by *V. kershawi* were to plants that were flowering abundantly. Generally, there seemed to be sufficient amounts of nectar available for the relatively small number of butterflies (often only one) visiting any particular plant at a given time. However, it is possible that the introduced Honeybee *Apis mellifera* might significantly compete with native insects for nectar, when *A. mellifera* forages in large numbers on flowering plants (including some species with tubular flowers).

Kevan and Baker (1999) indicated that butterflies (with large wings) probably have a lower metabolic rate in flight than some other insects, such as hovering bumblebees and moths. The lower energy requirement of butterflies stems at least partly from their ability to regulate their temperature by basking in sunlight (Kevan and Baker 1983; Bernhardt 1999; Weiss 2001). So, *V. kershawi* may require smaller amounts of nectar (per gram of body weight) than some insects in some other orders, e.g. bees and hover flies. Kevan and Baker (1999) stated that competition between insect flower visitors has been little studied. They suggested that butterflies may be less dominant at flowers than some other insects, such as bumblebees and hover flies.

Kevan and Baker (1999) noted that the composition of nectar varies between different flower types and also between different plant families. They stated that open, bowl-shaped flowers tend to be hexose-rich and that their nectar tends to be concentrated, due to evaporation. They noted that the flowers of daisies also tend to be hexose-rich. Kevan and Baker (1983; 1999) also stated that flowers 'pollinated' by butterflies tend to be sucrose-rich. These are flowers with deep or 'concealed' nectaries (Proctor *et al.* 1996). For example, the notable 'butterfly bush' *Buddleja davidii* has nectar that is rich in sucrose (Baker and Baker 1983). There is also some indication that flowers 'pollinated' by butterflies may have higher levels of amino acids in their nectar (Kevan and Baker 1999).

Flower Configuration and Abundance

Kevan and Baker (1983) noted that the packing of flowers into dense inflorescences saves foraging insects energy. They also noted that walking generally uses far less energy than hovering flight, when insects are foraging on flowers. Faegri and van der Pijl (1979) stated that 'typical' butterfly blossoms, such as *Lantana* and *Buddleja*, have their flowers aggregated into dense masses and that this minimises 'travel costs'. May (1988) studied the flower selection and foraging energetics of two butterfly species in Florida, USA. He found that the more densely packed flowers visited by the butterflies in his study

Fig. 3. *Vanessa kershawi* feeding on nectar of *Senecio madagascariensis* (Asteraceae).

area tended to provide less energy per flower. This was because these flowers tended to be smaller and consequently produced less nectar per flower than the larger, but less densely packed flowers. He concluded that the flowers with longer corollas tended to be more profitable for the two butterfly species in his study area. Corbet (2000) found that the Painted Lady *Vanessa cardui* tended to visit flowers massed in dense inflorescences, at a study site in Britain.

The flowers visited by *V. kershawi* in the bushland of northern Sydney were often clustered closely together on plants that were flowering abundantly. This often enabled the butterfly to walk over the plant from one flower to the next, e.g. when visiting Tick Bush *Kunzea ambigua* (Fig. 1) and Small-leaved Privet flowers. Foraging in such a way would be likely to help the butterfly to conserve energy.

The individual flowers of Slender Rice Flower, Lantana and the florets of daisies are not large and each may yield a relatively small amount of nectar. However, these flowers are packed densely together in 'heads'. This enables a butterfly to perch on a 'head' of flowers and feed in rapid succession from numerous flowers, in an energy efficient manner. Also, the flowers of the Broad-leaf Grass-tree are arranged in long vertical 'spikes', enabling the butterfly to walk easily between individual flowers as it feeds. Such feeding efficiencies probably assist *V. kershawi* to live within the constraints of its energy budget.

Flower Colour

An important role of flower colour may be to attract the butterfly (and other insects) from a distance, particularly when plants are flowering abundantly. Weiss (2001) suggested that butterflies use long-distance visual cues to locate nectar sources. However, according to Rutowski (2003) it is not known whether butterflies use visual cues to locate nectar sources at distances greater than a few metres. At closer distances, flower colour is important in helping the butterfly to recognize and locate flowers (Rutowski 2003) and in guiding insects to the precise source of nectar (Kevan and Baker 1983). Faegri and van der Pijl (1979) stated that it was not known whether nectar guides 'mean anything' to butterflies. Rutowski (2003) indicated that butterflies tend to visually detect resources (such as flowers) at distances of up to one or two metres and that visual recognition of such resources mostly takes place at distances of a few centimetres.

Briscoe (2003) noted that there is considerable variation in the number of spectral classes of photoreceptors in the compound eyes of different moth and butterfly species. For example, some butterflies in the family Nymphalidae have been found to possess three or four spectral classes of photoreceptors, whereas some of the Hesperiidae have only three. The retina of the Asian Yellow Swallowtail *Papilio xuthus* (Papilionidae) has five spectral classes of photoreceptors (red, green, blue, violet and ultraviolet), placing it amongst the most complex of the butterfly retinas that have been studied (Briscoe 2003). True colour vision has been confirmed, by means of behavioural experiments, in *P. xuthus* (Kinoshita *et al.* 1999) and the Orchard Swallowtail *Papilio aegeus* (Kelber and Pfaff 1999).

The spectral responses and photoreceptors of the compound eye of a number of butterfly species in the family Nymphalidae were studied by Eguchi *et al.* (1982), Steiner *et al.* (1987) and Kinoshita *et al.* (1997). For example, Steiner *et al.* (1987) found evidence to suggest that the compound eye of the Small Tortoiseshell *Aglais urticae* was sensitive to ultraviolet, blue and green light.

Briscoe *et al.* (2003) found that the compound eye of the Painted Lady *Vanessa*

cardui has three types of photoreceptors (green, blue and ultraviolet) and that this species apparently lacks red-absorbing visual pigments. Horridge *et al.* (1984) also could not find evidence of red-sensitive photoreceptors in the eye of the Yellow Admiral *Vanessa itea*. Briscoe and Bernard (2005) found that representatives of four other genera of nymphalid butterfly, closely related to *Vanessa*, also evidently lacked red-sensitive photoreceptors. This evidence, taken together, indicates that *V. kershawi* is probably unable to see the colour red. It also seems likely that the compound eye of *V. kershawi* is sensitive to green, blue and ultraviolet light.

Butterfly vision is significantly different from human sight. For example, it is possible that *V. kershawi* might be attracted to ultraviolet light reflecting from some flowers. Such reflections are invisible to the naked human eye. Dyer (1996) studied the reflection of near-ultraviolet (UVA) radiation from the flowers of a number of Australian native plants. He studied twenty white-flowered species, all of which did not reflect UVA radiation. For example, he found that the UVA reflection for a white-flowered *Pimelea* sp. was 'dark'. None of the other plant species studied by him corresponds with species recorded in this present study, as food plants of adult *V. kershawi*.

Weiss (2001) noted that innate colour preferences have been recorded for foraging butterflies in the families Nymphalidae, Papilionidae and Pieridae. She indicated that such colour preferences may vary between genera within a family, between species within a genus and even between the sexes of a given species. Briscoe (2003) indicated that the reason for these preferences is not well understood.

Nunn (2002) conducted an experiment, the results of which implied that *V. kershawi* might possibly have shown some preference for yellow artificial 'flowers' over white or purple artificial 'flowers'. However, the butterflies that she tested were captured from 'the wild', so it is possible that they might have already learned to favour yellow flowers. To unequivocally determine an innate colour preference (and exclude the possible influence of learning), it might be necessary to use methods similar to those employed by Kinoshita *et al.* (1999).

The Painted Lady *V. cardui* is similar to *V. kershawi* and is common and widespread in North America, Europe, Asia and Africa (Braby 2000). Janz (2005) noted that *V. cardui* is an opportunistic species, capable of annually colonizing large areas in the temperate portions of the world during spring. Bennett (1883) studied *V. cardui* at one site in Britain. He found that *V. cardui* visited Common Knapweed *Centaurea nigra* and Greater Knapweed *C. scabiosa* (Asteraceae). Both of these species have purple (or 'reddish-purple') flowers. Corbet (2000) observed adults of *V. cardui* feeding on a variety of flowers at a site in Britain. Janz (2005) indicated that selection of nectar sources by *V. cardui* may be determined largely by local abundance and availability. He noted that it may be unusual for *V. cardui* to use the same plant species for both nectar and larval food, at any given locality. In Australia, *V. cardui* has been recorded in only a few localities in Western Australia, and then only sporadically, suggesting that it is not permanently established there (Braby 2000; Braby 2004). This precludes a comparative study of the adult feeding behaviour of *V. kershawi* and *V. cardui* in the wild, in south-eastern Australia.

A study by Kay (1982) found that the Red Admiral *Vanessa atalanta* strongly preferred purple flowers of a common European herb, Devil's-bit Scabious *Succisa pratensis* (Dispacaceae), over white flowers of the same plant species. Kay suggested that such a pattern of discrimination may involve an innate or fixed colour preference in the butterfly. Scherer and Kolb (1987) observed that the feeding reaction of the Small Tortoiseshell *Aglais urticae* (Nymphalidae) was elicited by the yellow and blue regions of the spectrum (possibly also indicating an innate colour preference).

Weiss (1995) reported that the Gulf Fritillary *Agraulis vanillae* (Nymphalidae) can learn to favour one colour of flower over another, depending on the amount of nectar provided by the flower. She indicated that this capacity for associative colour learning is likely to be widespread amongst flower-foraging butterflies. Weiss (2001) noted that foraging butterflies can quickly learn to associate a sugar reward

with a particular colour and that they can rapidly learn to switch their colour preferences when a previously unrewarding colour is made rewarding.

Flowers visited by *V. kershawi* in northern Sydney bushland were mostly white. All of the native plants visited had white or cream coloured flowers. It seems plausible that this does not indicate a flower colour preference by *V. kershawi*, but rather that the best available native nectar sources happened to be predominantly white coloured flowers. The weed species visited by *V. kershawi* had white, yellow, purple or orange flowers.

No discernable preference for one particular flower colour was noticed in the foraging behaviour of adult *V. kershawi* in the study area. However, this study was not designed to detect such a preference. Flower colour preference may not be an overriding factor in the selection of nectar sources by *V. kershawi*, in the bushland of northern Sydney. It seems plausible that an abundant source of readily accessible nectar would be sought by this butterfly, almost regardless of the flower colour. There are obvious survival advantages for such a widespread, migratory species in not being rigidly selective about the colour of flowers from which it feeds. It seems likely that such a common and widespread species would tend to be somewhat opportunistic and flexible in its selection of nectar sources. Such flexibility may well involve learning abilities similar to those discussed by Weiss (1995; 2001).

Whether *V. kershawi* would readily feed from red flowers remains to be determined. Red is probably somewhat less abundant than white, as a flower colour in the bushland of northern Sydney, where red-coloured flowers tend to be fed upon primarily by birds. For example, Pyke (1983) found that the flowers of Mountain Devil *Lambertia formosa* and Red Spider Flower *Grevillea speciosa* are visited by honeyeaters (Meliphagidae). As mentioned above, it seems unlikely that *V. kershawi* can see the colour red.

Flower Scent

Apparently, it is not known whether scent plays any role in attracting *V. kershawi* to feed on flowers. Kevan and Baker (1999) stated that 'butterfly-pollinated flowers' are mostly weakly scented, but that butterflies can orient strongly to olfactory cues. Proctor *et al.* (1996) indicated that some butterfly species are evidently capable of using scent to search for food. Barth (1985) stated that some butterflies in the family Nymphalidae use olfaction to find their food. Raguso and Willis (2003) indicated that floral scent has been found to attract some species of Nymphalidae from a distance and can also prompt some butterflies in this family to land on and probe flowers. Pellmyr (1986) found that three species of Fritillary (Nymphalidae) were strongly attracted to the scented morph of the Japanese herb *Cimicifuga simplex* (Ranuneulaceae), but the butterflies were not very responsive to scentless plants of the same species.

Proctor *et al.* (1996) suggested that scent may attract some butterflies from a distance, alerting them to start searching for a food source, and that it also may act as a recognition signal for food sources that previously have been used by some butterfly species. Proctor *et al.* (1996) noted that some butterfly species first react to scent at a distance of 20 centimetres, whereas others can apparently react to scent at a distance of 30 metres (extending to 60 metres with a favourable wind). They also stated that the Red Admiral *Vanessa atalanta* has been found to use both visual and olfactory cues to seek food (consisting of flowers, dung and sap). However, some other butterfly species apparently do not respond to scent when seeking food.

Musgrave (1972) reported that Tick Bush flowers have a very strong scent and he suggested that this 'almost sickly-sweet aroma' may act as an attractant to insects. *Kunzea ambigua* flowers are quite often visited by *V. kershawi* (Fig. 1) and also by other species of butterfly in the bushland of northern Sydney (pers. obs.). However, it is not clear whether these butterflies are attracted to the scent of *K. ambigua* flowers.

Pollination

Bernhardt (1999) noted that relatively few plants are pollinated exclusively by butterflies. Quantitative data on the performance of butterflies as pollinators are somewhat scarce (Weiss 2001). An indi-

vidual butterfly species may effectively pollinate some, but not all, of the plant species visited by the butterfly for nectar (Murphy 1984; Jennersten 1984).

Wiklund *et al.* (1979) studied the Wood White *Leptidea sinapis* (Pieridae) in Sweden and concluded that this butterfly was probably not an effective pollinator of the flowers that it visited for nectar. They suggested that this butterfly species may have been acting as a 'nectar thief'. Murphy (1984) suggested that this may have been because the flowers that were visited by *L. sinapis* happened to be structurally unsuited to pollination by butterflies. A study conducted by Courtney *et al.* (1982) in England indicated that some butterfly species, including the Small Tortoiseshell *Aglais urticae* (Nymphalidae), may be important in transporting pollen over distances of many kilometres. Murphy (1984) reported that the Checkerspot Butterfly *Euphydryas editha* (Nymphalidae), in California, USA, can carry large amounts of some pollen types on its body and wings. He also considered that this butterfly was a likely pollinator of a number of plant species. Jennersten (1984) found that butterflies in Swedish meadows were probably only minor pollinators of the majority of plant species visited and were probably stealing nectar from the flowers of 'legumes' (Fabaceae, subfamily Faboideae). Schmitt (1980) suggested that even a small amount of pollination by butterflies can increase the dispersal of genes within a plant population. She studied three species of *Senecio* (Asteraceae) in the Rocky Mountains, Colorado, USA, and found that butterflies can carry and transfer pollen between *Senecio* plants.

There apparently has been little information published about the specific effectiveness of butterflies as pollinators of plants in Australia. Keighery (1975) suggested that some butterfly species, including *V. kershawi*, were probably effective pollen vectors for a number of species of *Pimelea* in Western Australia. Hopper (1980) found some evidence to suggest that butterflies may be minor pollinators of *Syzygium tierneyanum* (Myrta-ceae) in northern Queensland. Also, the observations made by Ireland and Griffin (1984) suggested that butterflies may be relatively minor pollen vectors for the Yellow Stringybark *Eucalyptus muelleriana* in Victoria. Hawkeswood (1985) concluded that butterflies were probably not important pollinators of Corkwood Wattle *Acacia bidwillii* (Mimosaceae) at Townsville, Queensland. House (1997) noted that butterflies have been recorded transporting eucalypt pollen.

Vanessa kershawi may play a role in the pollination of many of the plants listed in Table 1, including the weed species. Given that *V. kershawi* is a migratory species, its greatest significance as a pollinator may be in the long range dispersal of pollen between isolated stands of a given plant species. In NSW, large numbers of *V. kershawi* can fly considerable distances over periods of up to 7-8 weeks, especially in the springtime (Braby 2000). Such migratory flights are probably fuelled largely by nectar and the migrating butterflies may pause quite often to feed on flowers. While making prolonged migratory flights, many Lepidoptera feed along the way (Johnson 1969). The main migration of *V. kershawi* in NSW can start any time between mid August and late November and there is some evidence of a smaller return movement between February and April (Smithers and Peters 1966; Smithers 1969; Braby 2000).

Many of the species of plants visited by *V. kershawi* in this study (Table 1) flower at times of the year when *V. kershawi* could be migrating. Many of these plant species are common, widespread and produce abundant flowers. For example, Tick Bush *Kunzea ambigua* occurs commonly in many of the sandstone bushland areas of northern Sydney. When in flower, *K. ambigua* produces abundant nectar and is quite often visited by *V. kershawi* (Fig. 1), as well as numerous other nectar-dependent insect species, including other species of butterfly (Musgrave 1972; Benson and McDougall 1998; pers. obs.). Whilst native bees and the introduced Honeybee *Apis mellifera* may be amongst the most effective pollinators of *K. ambigua* over short to medium distances, it is possible that migratory butterflies (and perhaps also migrating moths) may play a role in the pollination of *K. ambigua* and other plant species over longer distances.

Conclusions

The majority of plants visited by adults of *Vanessa kershawi* for nectar in the study area were native species, predominantly in the family Myrtaceae. Most of the plants visited were dicotyledons. The growth forms of the plants visited by *V. kershawi* for nectar ranged from herbs, through to shrubs and one species of tree. Most of the flowers visited were white or cream coloured. Other flower colours visited were yellow, purple and orange. No discernible preference for one particular flower colour was noticed in the foraging behaviour of adult *V. kershawi* in the study area. However, this study was not designed to detect such a preference. It may be that an abundant source of readily accessible nectar would be sought by *V. kershawi*, almost regardless of the flower colour. (However, *V. kershawi* may not be able to see the colour red). It seems plausible that such a common and widespread species would tend to be flexible and somewhat opportunistic in its selection of nectar sources.

A variety of flower shapes were fed upon by *V. kershawi* in the study area, ranging from tubular to very open or broadly dish-shaped flowers. Open flowers appeared to be visited as often as, if not more frequently than, tubular flowers. *V. kershawi* was not observed feeding on plant sap in the study area.

As a migratory butterfly species, *V. kershawi* may be involved in the long-range pollination of a number of common native and exotic plant species. However, the effectiveness of *V. kershawi* as a pollinator requires further research.

Not much is known about the extent to which the diet of adults of *V. kershawi* varies across Australia. Nectar from native plants in the family Myrtaceae may provide a major portion of the diet of adult *V. kershawi* in the forests and woodlands of northern Sydney. Whether this also may apply in other forested areas of coastal Australia could be worth investigating. Another possible line of enquiry is whether scent plays a role in attracting this species of butterfly to flowers.

In conclusion, much remains to be learnt about the foraging behaviour and ecology of adults of *V. kershawi* and also of other Australian butterflies.

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